may be applied to the positive stop torque shoulder prior to final make up, without causing irreversible plastic deformation.

[0027] The pin member 12 or the box member 10 defines the longitudinal axis of the made-up connection. The roots and crests of the box and pin members are flat and parallel to the longitudinal axis of the connection and have sufficient width to prevent any permanent deformation of the threads when the connection is made up.

[0028] In one embodiment, the invention is a two-step wedge thread form with a positive stop torque shoulder. As shown in FIGS. 2 and 3, the positive stop torque shoulder can be located at the interface of the box face/pin OD shoulder 24, located at the interface between the two thread steps 26, or located at the interface of the pin nose/box ID shoulder 28.

[0029] Referring to FIG. 2, connection 8 includes a box member 14 and a pin member 16. Box member 14 has two thread steps each having a tapered, internal, generally dovetail-shaped thread structure formed thereon and adapted for engaging complementary tapered, external, generally dovetail-shaped thread structure formed on the two thread steps of pin member 16 to mechanically secure the box and pin members in a releasable manner.

[0030] Internal thread on each step of box member 14 has stab flanks, load flanks, roots, and crests. The thread increases in width progressively at a uniform rate in one direction substantially the entire helical length of thread. External thread on each step of pin member 16 has stab flanks, load flanks, roots, and crests. The thread increases in width progressively at a uniform rate in the other direction substantially the entire helical length of thread. The oppositely increasing thread widths and the taper of threads, cause the complementary roots and crests of the respective threads to move into engagement during make-up of the connection. Root and crest engagement is followed by the moving of complementary stab and

load flanks into engagement upon make-up of the connection. The moving of complementary flanks, roots and crests into engagement forms sealing surfaces that resist the flow of fluids between the threads. One or more positive stop torque shoulders may be located at the box face/pin OD 24, the pin/box interface between the two thread steps 26, or the pin nose/box ID 26.

[0031] The one or more positive stop torque shoulders may move into engagement upon make-up of the connection. The positive stop torque shoulder engagement may occur simultaneously with the stab and load flanks moving into engagement. Alternatively, the stab and load flanks may move into engagement after root and crest engagement during make-up of the connection and followed by the positive stop torque shoulder engagement upon make-up of the connection. In a preferred embodiment, the internal and external thread widths are selected so that a selected clearance exists at least between the internal and external load and stab flanks, upon engagement of the positive stop torque shoulder. In this arrangement, torque may be applied to the positive stop torque shoulder prior to final make up, without causing irreversible plastic deformation.

[0032] The pin member 16 or the box member 14 defines the longitudinal axis of the made-up connection. The roots and crests of the box and pin members are flat and parallel to the longitudinal axis of the connection and have sufficient width to prevent any permanent deformation of the threads when the connection is made up.

[0033] Those skilled in the art will appreciate that additional embodiments can be configured with combinations of multiple positive stop torque shoulders as specified above. It is also understood that additional embodiments can be configured with conical metal-to-metal seals or combinations of conical metal-to-metal seals located at the pin nose/box ID interface, the pin/box mid section interface and the box face/pin OD interface in combination with all applicable

wedge thread and positive stop torque shoulder options. Exemplary detailed embodiments are described below with reference to FIGS. 4a-d, 5a-e, and 6a-f.

[0034] Thread forms in accordance with embodiments of the invention may incorporate torque shoulders, metal-to-metal seals, or combinations thereof. FIGS. 4a-d show some possible torque shoulders configurations in accordance with the invention. FIG. 4A shows a square torque shoulder, or one in which the pin and box members each have a 90° torque shoulder. FIG. 4b shows a angled torque shoulder, or one in which the pin and box members each have a torque shoulder with an angle other than 90° that is matched with the other such that the faces of the torque shoulders are in parallel contact.

[0035] FIGS. 4c and 4d show torque shoulder configurations with mismatched angles. Torque shoulders with mismatched angles include either the pin or box member having a torque shoulder with a larger angle than the complementary torque shoulder such that the faces of the torque shoulder are not in parallel contact. FIG. 4c shows a configuration where the pin member has a torque shoulder with a larger angle than the torque shoulder on the box member. FIG. 4d shows a configuration where the box member has a torque shoulder with a larger angle than the torque shoulder on the pin member.

[0036] FIGS. 5a-e show metal-to-metal seals in accordance with embodiments of the invention. A Metal-to-metal seal can exist at the pin nose/box ID, the box face/pin OD or on a two step thread form at the interface between the two steps. The metal-to-metal seals can be matched or mismatched. Matched metal-to-metal seals have contacting surfaces that are parallel to one another while mismatched metal-to-metal seals have contacting surfaces are not parallel to one another. FIG. 5a shows a matched metal-to-metal seal with an ID shoulder located at the pin nose/box ID. FIG. 5b shows a matched metal-to-metal seal with an open bore at the pin nose/box ID. FIG. 5c shows a mismatched metal-to-metal seal with an